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Kim et al.

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(54) **LIQUID CRYSTAL DISPLAY DEVICE AND METHOD OF MANUFACTURING THE SAME**

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(30) **Foreign Application Priority Data**

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G02F 1/1335 (2006.01)

(52) **U.S. Cl.**
CPC ***G02F 1/133305*** (2013.01); ***G02F 1/133377*** (2013.01); ***G02F 1/133512*** (2013.01)

(58) **Field of Classification Search**
CPC G02F 1/133394; G02F 1/133377; G02F 1/133512; G02F 1/133305
See application file for complete search history.

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(57) **ABSTRACT**

Disclosed are a flexible liquid crystal display (LCD) device and a method of manufacturing the same. The flexible LCD device comprises a first flexible substrate and a second flexible substrate. A layer is disposed on the first flexible substrate and first pixel control lines are disposed on the second flexible substrate. The LCD device also includes polymer walls disposed between the first flexible substrate and the second flexible substrate that maintain a cell gap between the first flexible substrate and the second flexible substrate. The polymer walls are substantially aligned with the first pixel control lines and light transparent gaps in the layer disposed on the first flexible substrate.

13 Claims, 15 Drawing Sheets

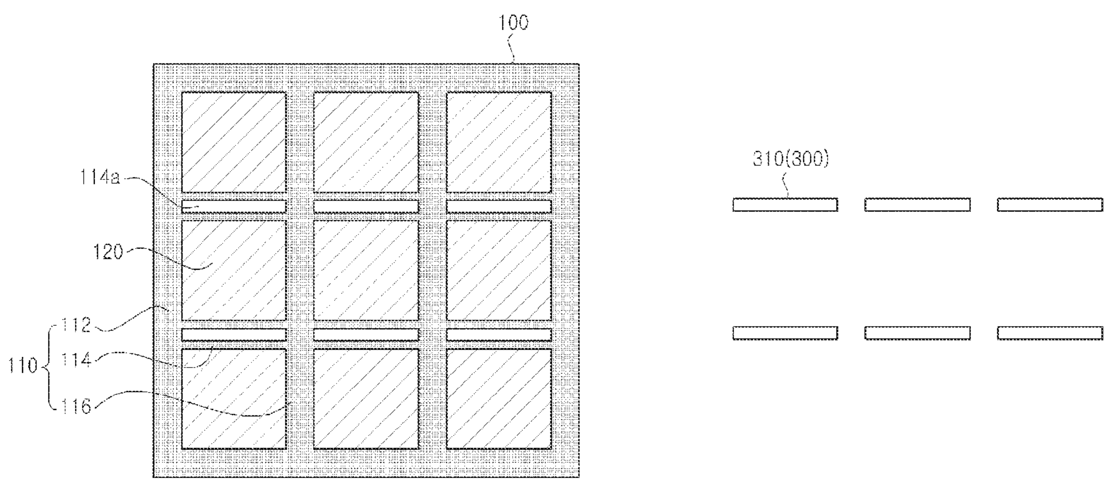


FIG. 1A

[Related Art]

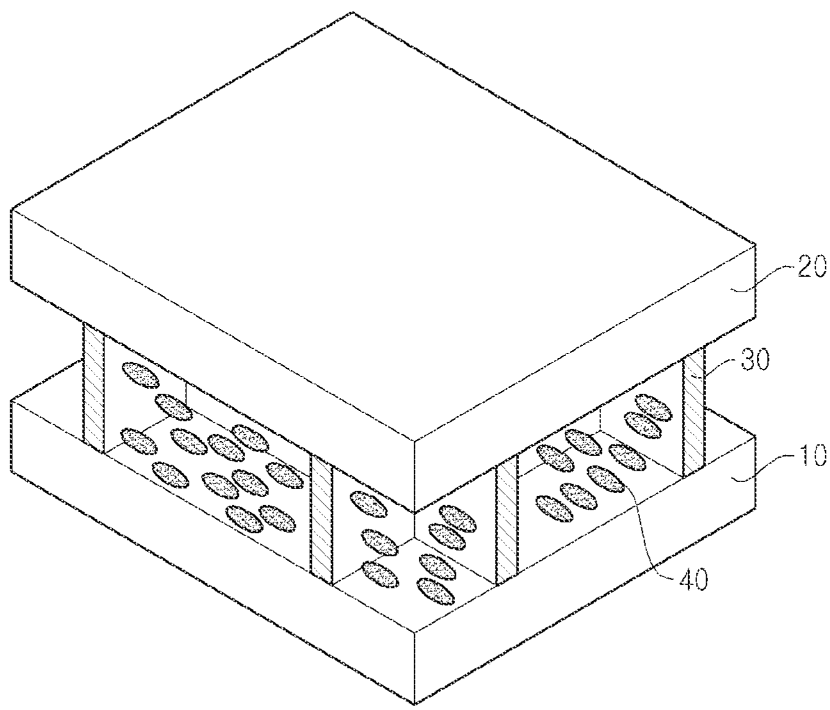


FIG. 1B

[Related Art]

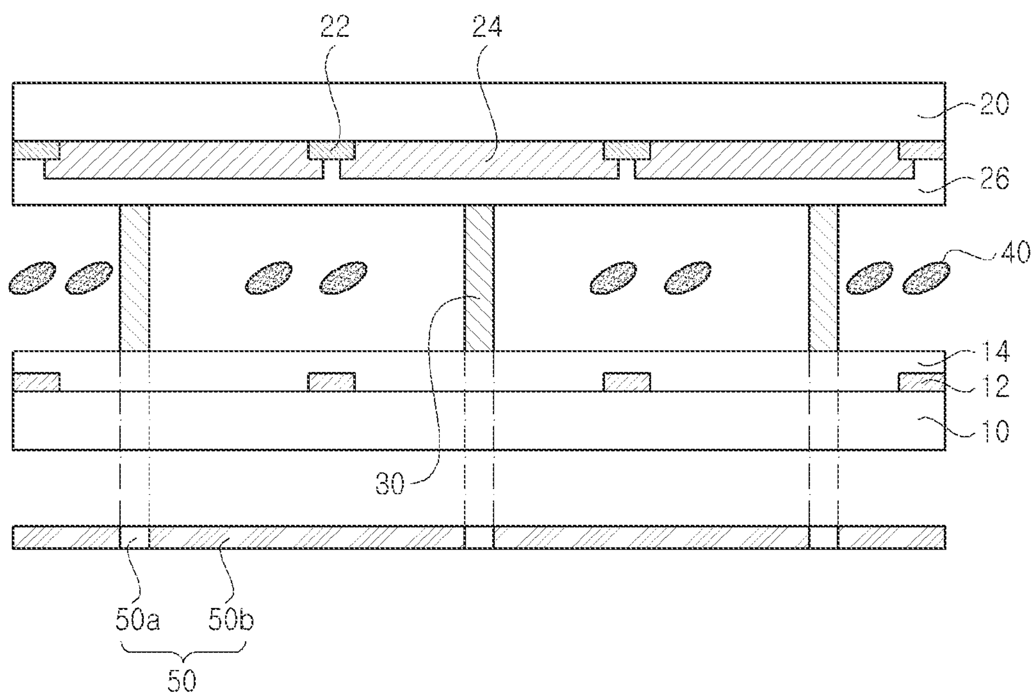


FIG. 2A

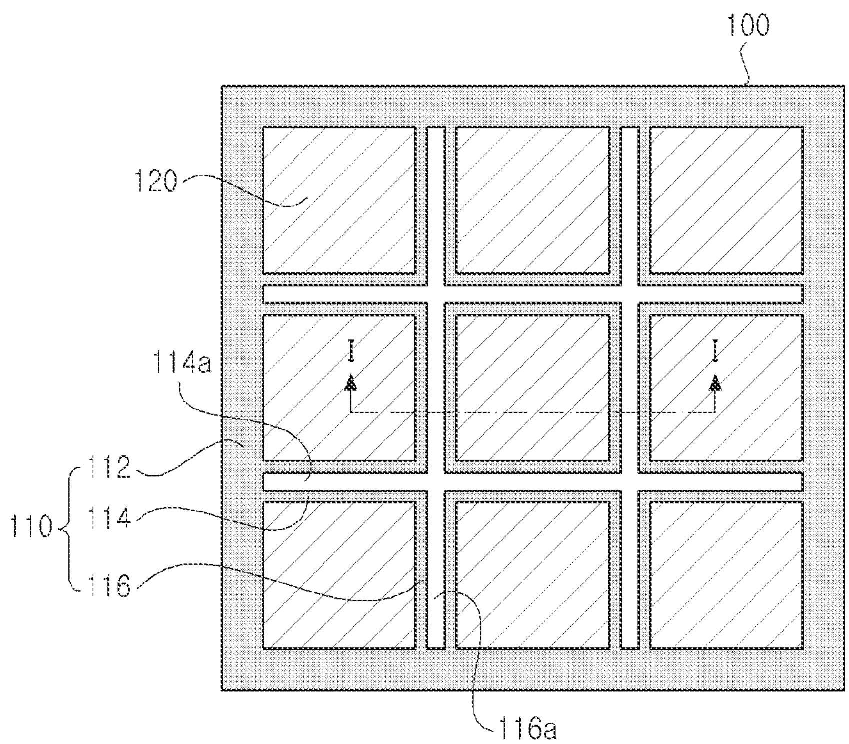


FIG. 2B

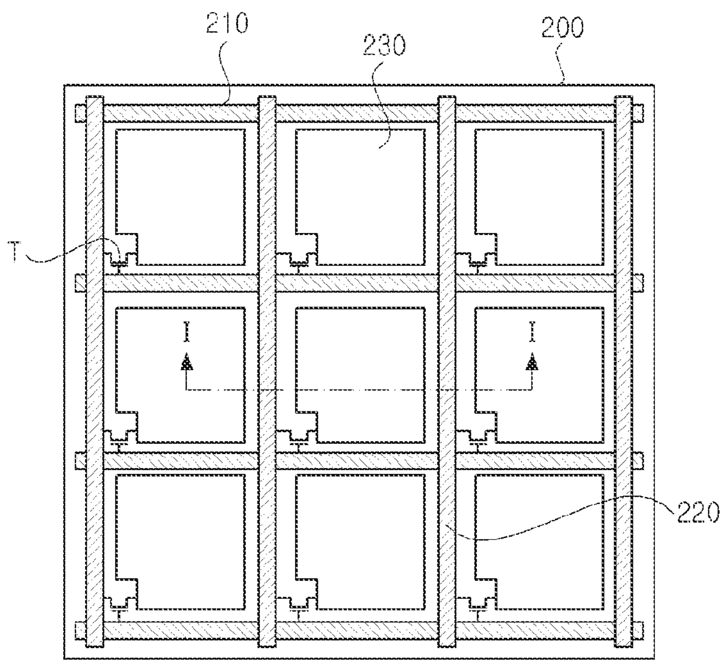


FIG. 2C

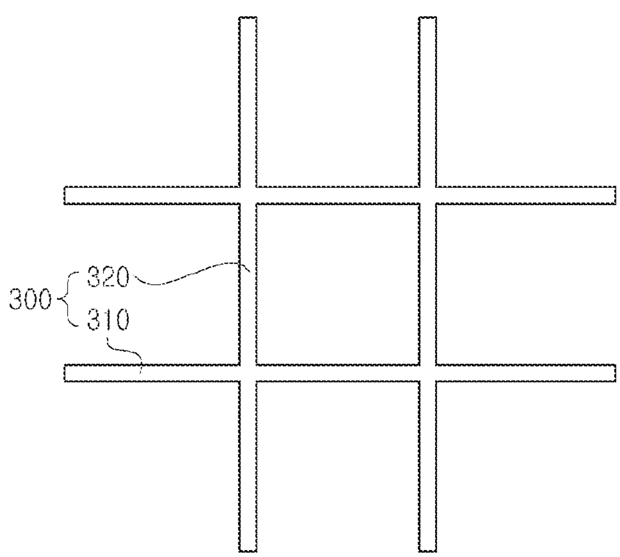


FIG. 2D

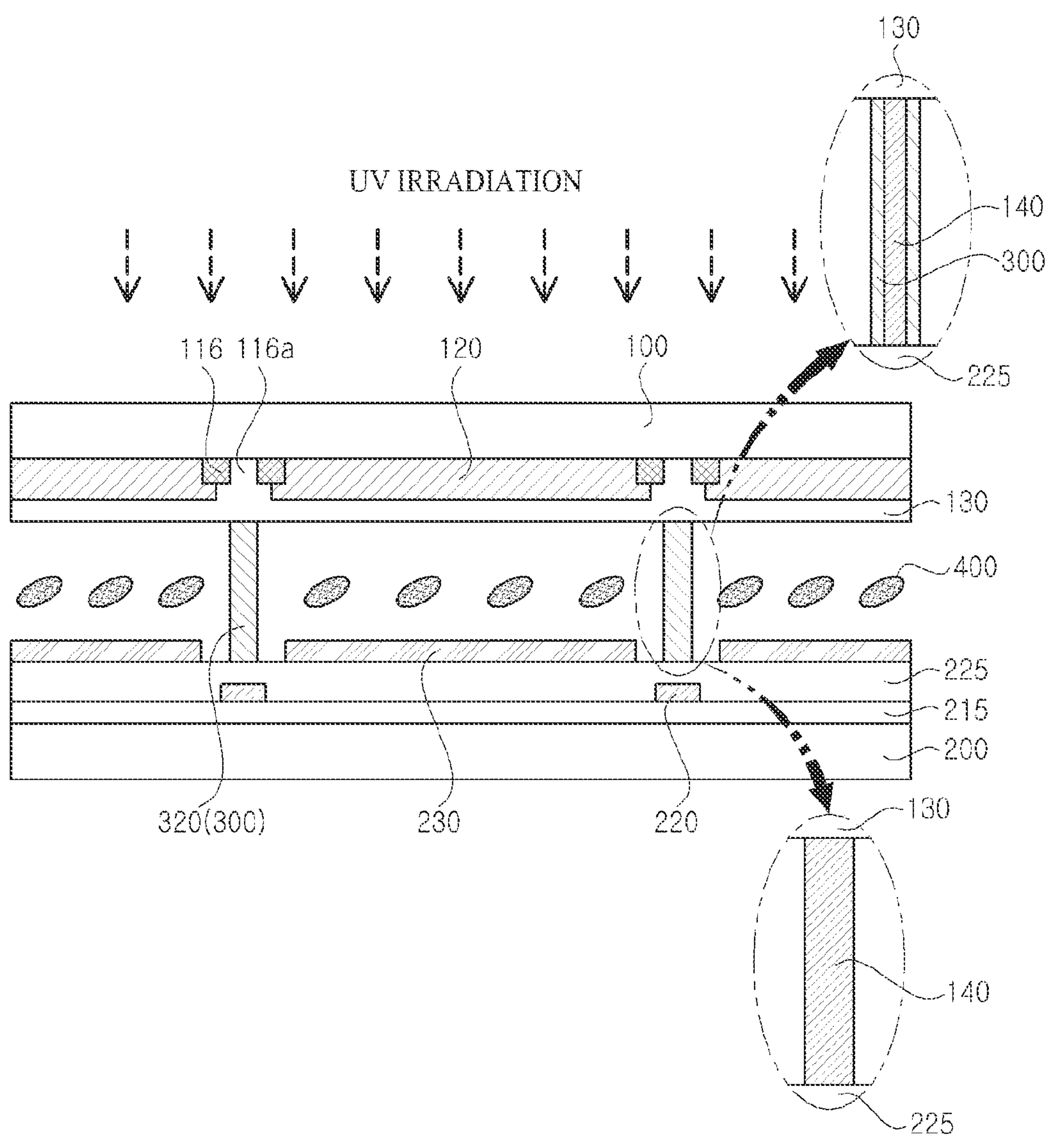

UV IRRADIATION
116
116a
120
100
130
400
225
215
200
320(300)
230
220
130
140
300
225
130
140
225

FIG. 3A

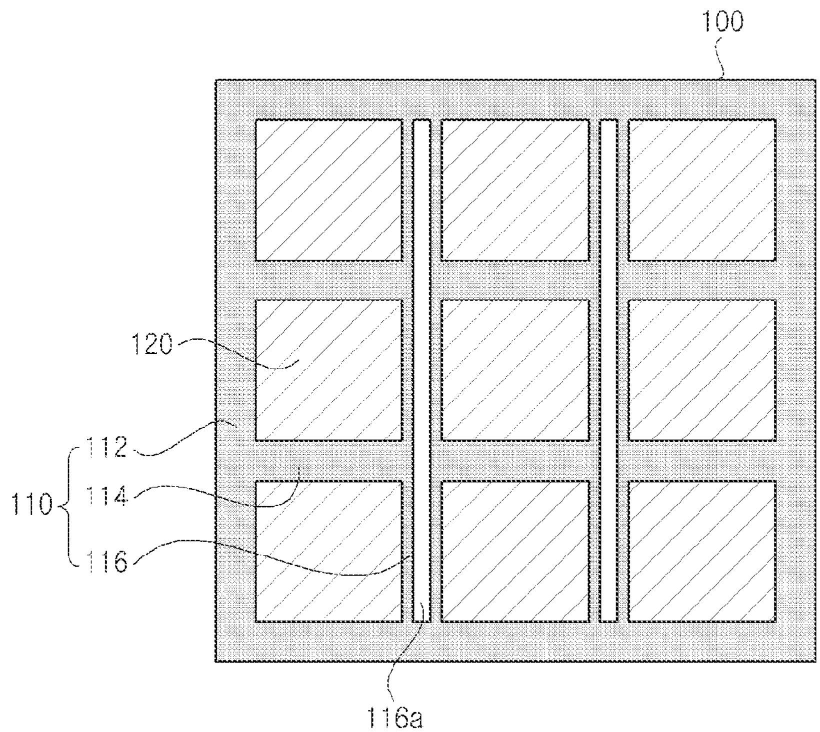


FIG. 3B

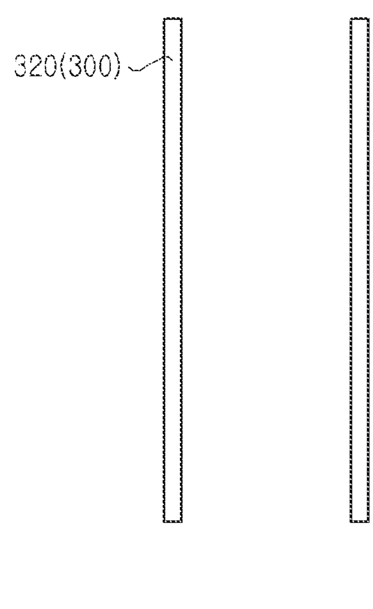


FIG. 4A

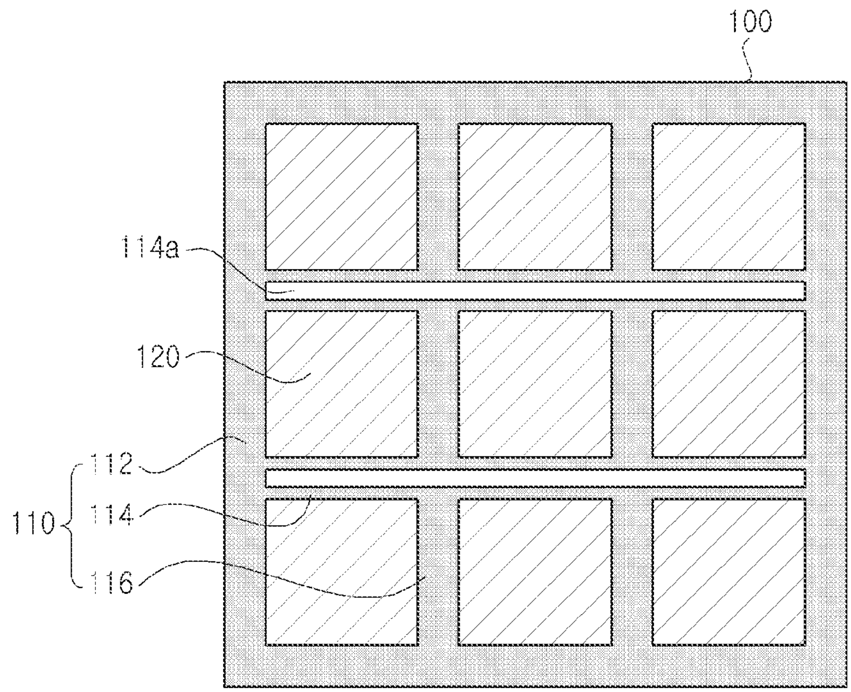


FIG. 4B

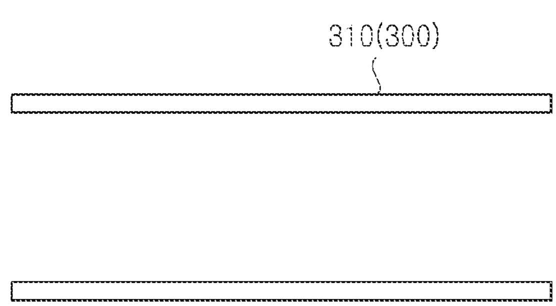


FIG. 5A

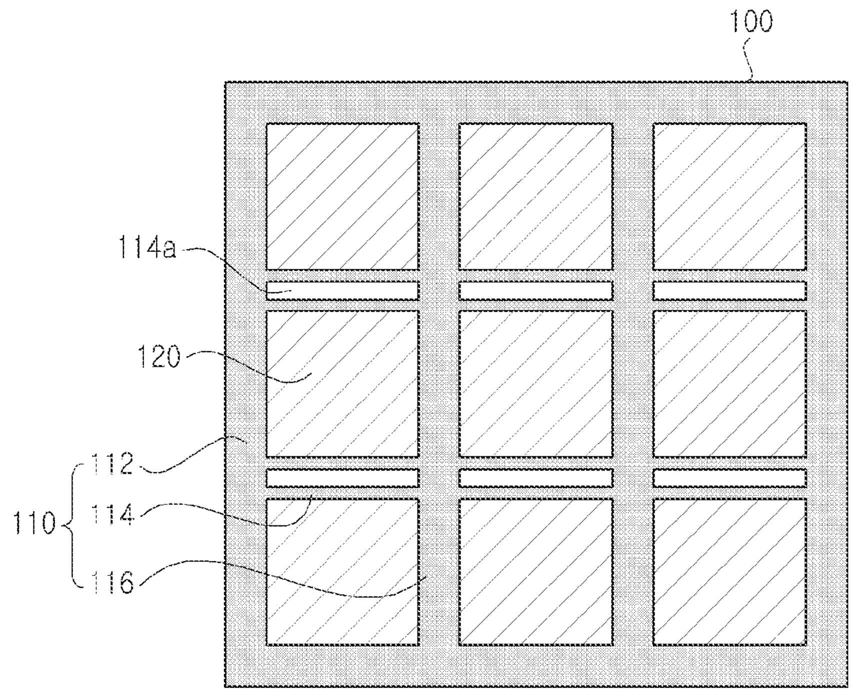


FIG. 5B

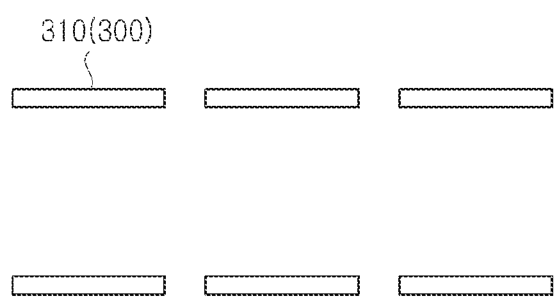


FIG. 6A

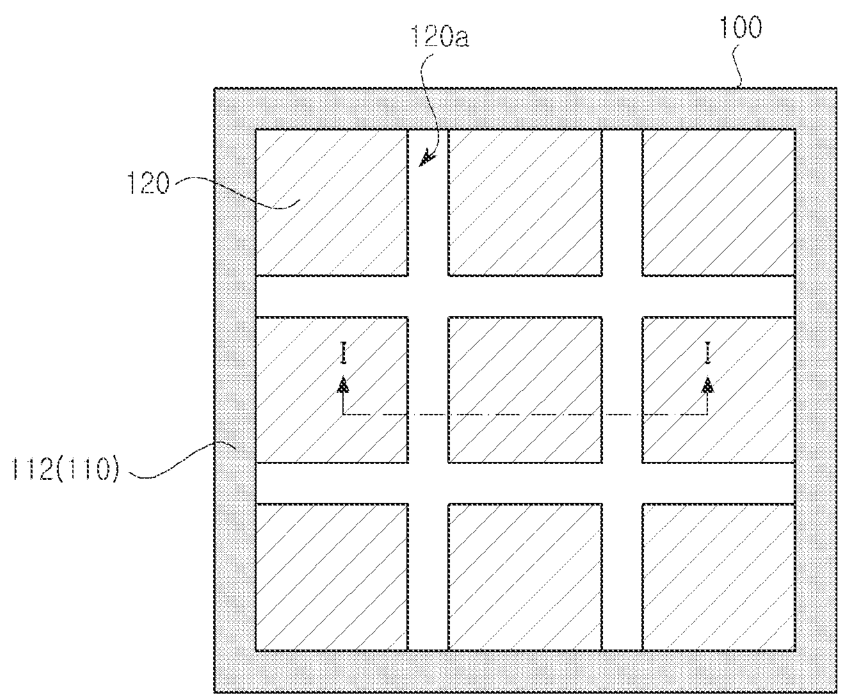


FIG. 6B

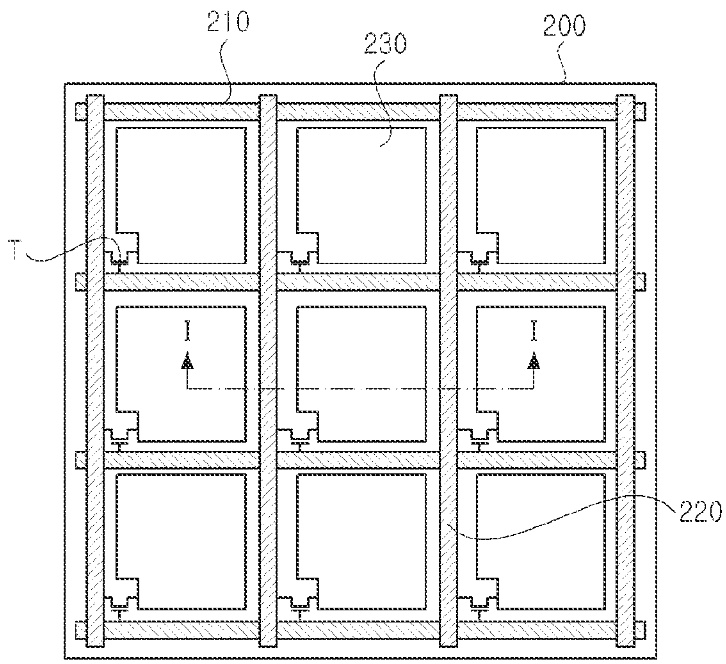


FIG. 6C

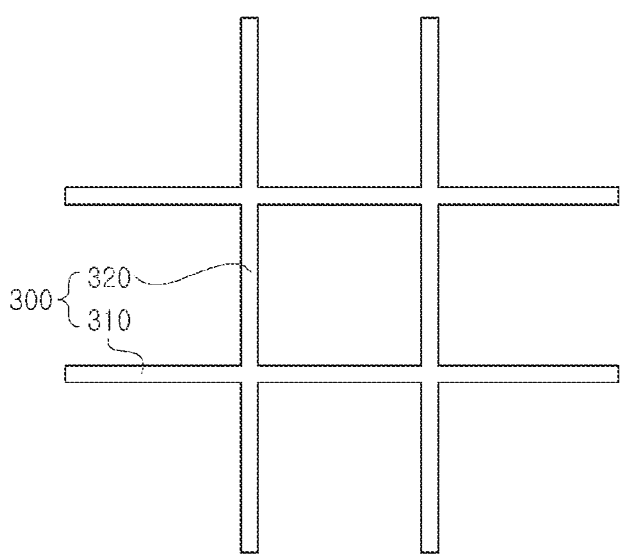


FIG. 6D

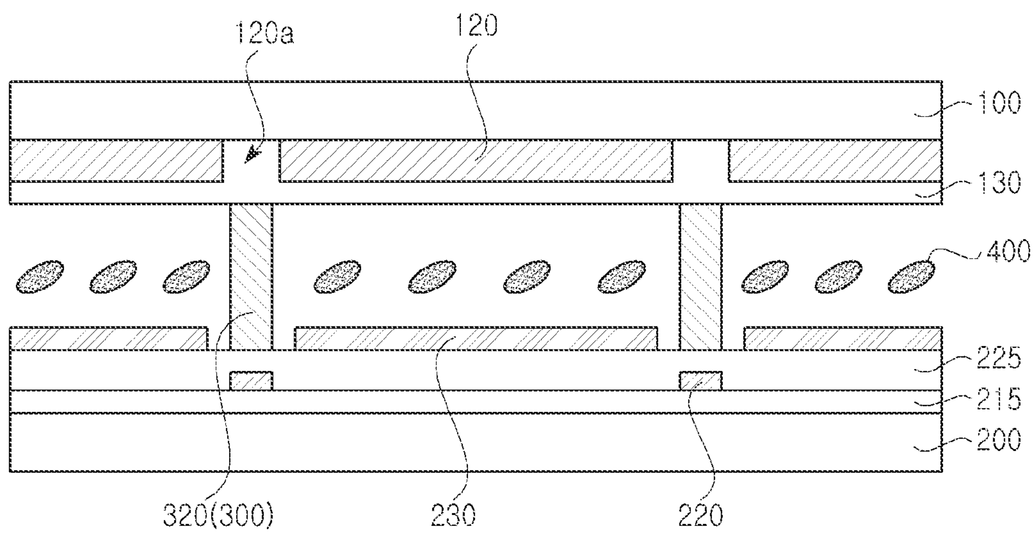


FIG. 7A

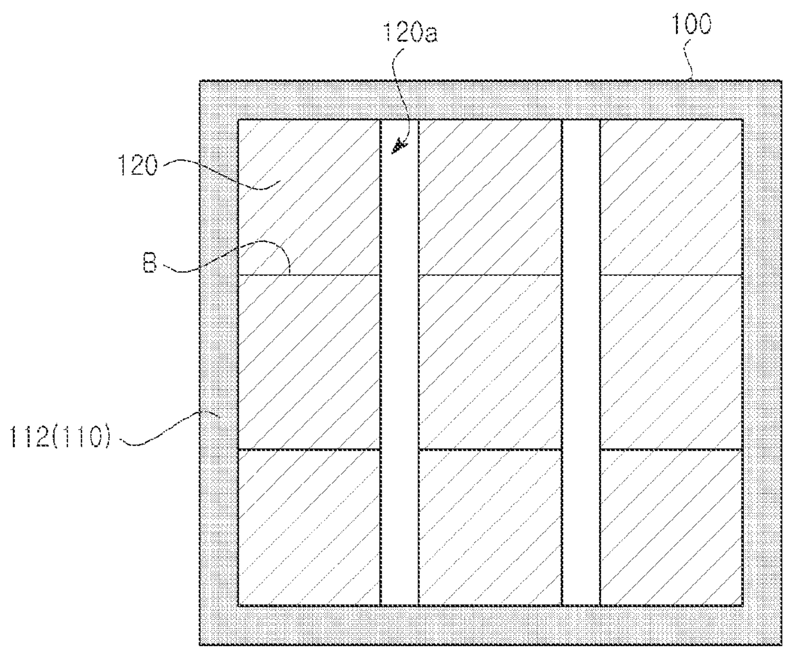


FIG. 7B

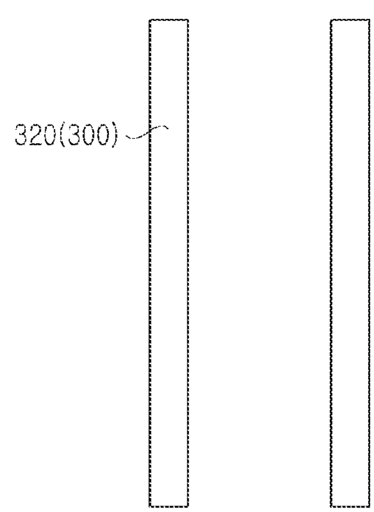


FIG. 8A

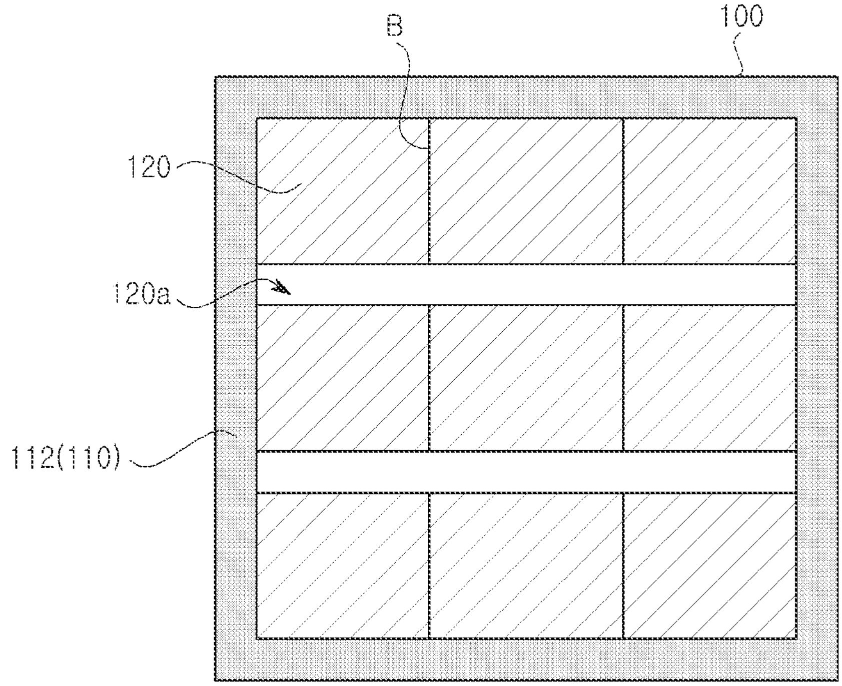


FIG. 8B

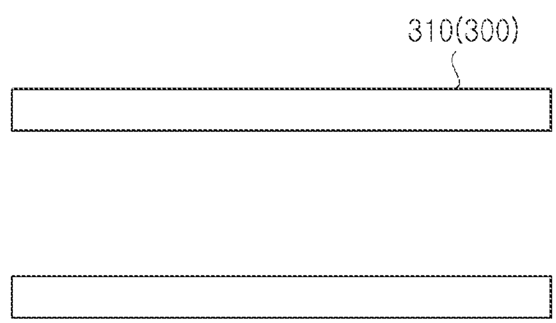


FIG. 9A

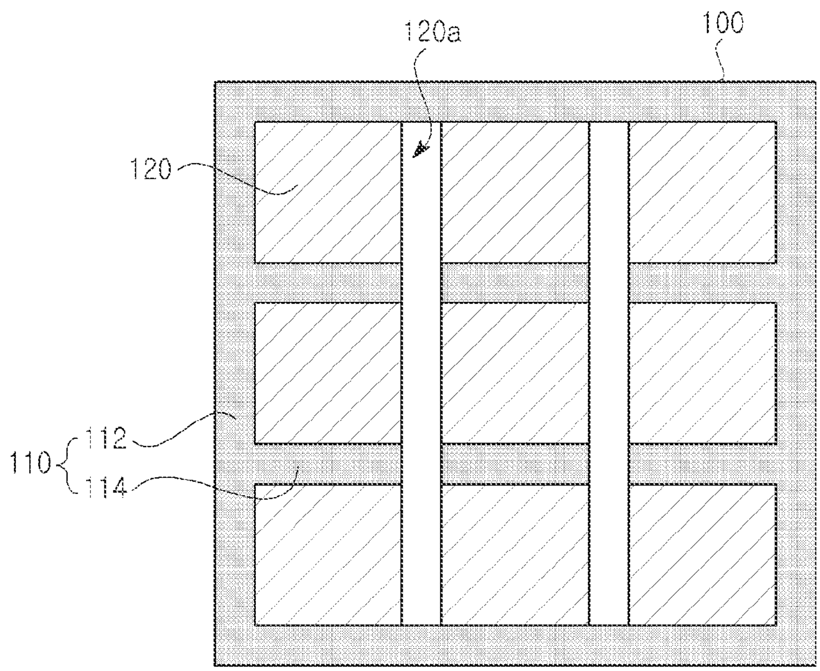


FIG. 9B

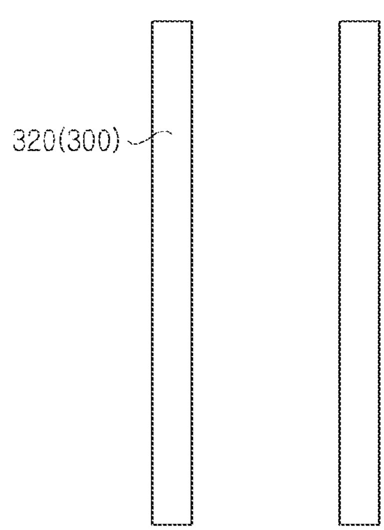


FIG. 10A

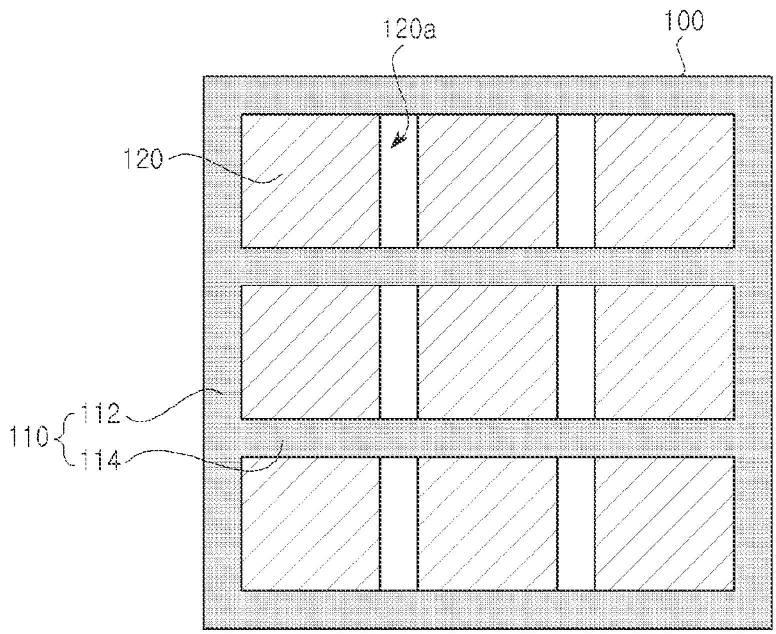
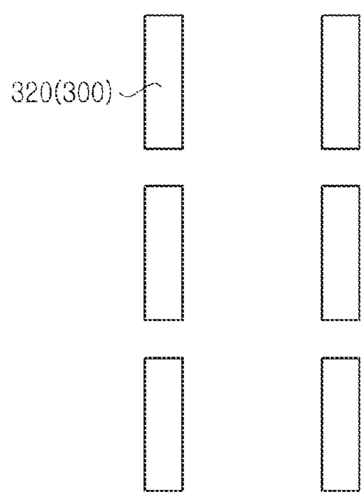


FIG. 10B



LIQUID CRYSTAL DISPLAY DEVICE AND METHOD OF MANUFACTURING THE SAME

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of the Korean Patent Application No. 10-2012-0117161 filed on Oct. 22, 2012, which is hereby incorporated by reference in its entirety.

BACKGROUND

1. Field of the Disclosure

The present invention relates to a liquid crystal display (LCD) device, and more particularly, to a LCD device including a polymer wall for maintaining a cell gap.

2. Discussion of the Related Art

Owing to advantages such as good portability and low power consumption by low operating voltage, a liquid crystal display (LCD) device is widely used in various fields of notebook computer, monitor, spacecraft, aircraft, and etc.

The LCD device includes a lower substrate, an upper substrate, and a liquid crystal layer formed between the lower and upper substrates.

Recently, there is an increasing interest in flexible LCD device based on a flexible plastic substrate. The flexible LCD device is a rollable or windable device, which is paperlike, whereby the flexible LCD device enables easy keeping and good portability. Owing to these advantages, the flexible display device has been steadily studied and developed as a next-generation display device.

However, when curving or bending the flexible LCD device, it may have a problem related with non-uniformity in cell gap between the lower and upper substrates. In order to overcome this problem of non-uniformity in cell gap, there has been proposed a method of applying a polymer wall between the lower and upper substrates.

Hereinafter, a related art LCD device including a polymer wall will be described as follows.

FIG. **1**A is a perspective view of a related art LCD device. FIG. **1**B is a cross sectional view of the related art LCD device.

As shown in FIG. **1**A, the related art LCD device includes a lower substrate **10**, an upper substrate **20**, polymer walls **30**, and a liquid crystal **40**.

The lower substrate **10** is arranged below the upper substrate **20**, and the polymer walls **30** are formed in a matrix configuration between the lower substrate **10** and upper substrate **20**. Also, the liquid crystal **40** is provided in a space between each of the polymer walls **30**. Thus, even though the related art LCD device is repeatedly curved or bent, a cell gap between the lower substrate **10** and upper substrate **20** is uniformly maintained owing to the polymer walls **30**.

The related art LCD device may be manufactured by processes of bonding the lower substrate **10** and upper substrate **20** to each other while providing a mixture of ultraviolet (UV)-curable compound and liquid crystal **40**, and forming the polymer wall **30** having a desired shape by irradiating the UV-curable compound with UV light. According to the irradiation of UV light, the UV-curable compound is cured with a phase separation from the liquid crystal **40**. Also, the liquid crystal **40** is positioned between each of the polymer walls **30**. The polymer wall **30** will be described in detail with reference to FIG. **1**B.

As shown in FIG. **1**B, lines **12** are formed on the lower substrate **10** of the related art LCD device, and a passivation layer **14** is formed on the lines **12**. On the upper substrate **20** of the related art LCD device, there are light-shielding layers **22**, a color filter layer **24** between each of the light-shielding layers **22**, and an overcoat layer **26** on the color filter layer **24**. Also, the polymer walls **30** are formed between the lower substrate **10** and upper substrate **20**, and the liquid crystal **40** is provided in the space between each of the polymer walls **30**.

As described above, the polymer wall **30** is formed by irradiating the UV-curable compound with UV light. Thus, in order to form the polymer wall **30**, the lower surface of the lower substrate **10** or the upper surface of the upper substrate **20** has to be irradiated with UV light.

However, the light-shielding layer **22** and color filter layer **24** formed on the upper substrate **20** have a low transmittance of UV light. Thus, if the upper surface of the upper substrate **20** is irradiated with UV light, it is difficult to form the polymer wall **30**. Meanwhile, in case of a COT (color filter on TFT) structure in which the color filter is formed on the lower substrate **10**, the polymer wall **30** may be formed by irradiating the upper surface of the upper substrate **20** with UV light. In this case, the structure of the LCD device is limited only to the COT structure.

For manufacturing various structures of a LCD device, the polymer wall **30** has to be formed by a UV irradiation onto the lower surface of the lower substrate **10**. That is, as shown in the drawings, a mask **50** including a transparent portion **50***a* and a non-transparent portion **50***b* is positioned below the lower substrate **10**, and then a UV irradiation is performed in such a manner that UV light is emitted from the lower side of the mask **50** to the lower surface of the lower substrate **10**. Accordingly, the UV-curable compound is irradiated with UV light penetrating through the transparent portion **50***a*, thereby forming the polymer wall **30**. In this case, the polymer wall **30** is formed in the same pattern as that of the transparent portion **50***a* of the mask **50**.

In this case, the lines **12**, such as gate lines or data lines, are formed on the lower substrate **10**, and the UV light cannot penetrate through the lines **12**. Accordingly, the transmission part **50***a* of the mask **50** is positioned to correspond with the other regions except the lines **12**. As a result, the polymer wall **30** is formed in the other regions except the lines **12**, that is, they are formed in a pixel region for displaying an image. Because the polymer wall **30** is formed in the pixel region for displaying an image, light transmittance of the LCD device is lowered, and thus luminance is also deteriorated.

SUMMARY

Accordingly, embodiments of the present invention are directed to an LCD device and a method of manufacturing the same that substantially obviate one or more problems due to limitations and disadvantages of the related art.

An aspect of embodiments of the present invention is directed to provide an LCD device and a method of manufacturing the same, which enables to manufacture various structures of LCD device owing to a polymer wall formed by a UV irradiation onto an upper surface of an upper substrate, and also prevents luminance deterioration owing to the polymer wall formed in a region corresponding to a gate line or data line.

Additional advantages and features of embodiments of the invention will be set forth in part in the description which follows and in part will become apparent to those having ordinary skill in the art upon examination of the following or may be learned from practice of embodiments of the invention. The objectives and other advantages of embodiments of the invention may be realized and attained by the structure particularly pointed out in the written description and claims hereof as well as the appended drawings.

In one embodiment, disclosed is a flexible liquid crystal display (LCD) device comprising a first flexible substrate and a second flexible substrate. A layer is disposed on the first flexible substrate and first pixel control lines are disposed on the second flexible substrate. The LCD device also includes polymer walls disposed between the first flexible substrate and the second flexible substrate that maintain a cell gap between the first flexible substrate and the second flexible substrate. The polymer walls are substantially aligned with the first pixel control lines and light transparent gaps in the layer disposed on the first flexible substrate.

In one embodiment, the layer disposed on the first flexible substrate is a color filter layer and the light transparent gaps are gaps in the color filter layer. Alternatively, the layer disposed on the first flexible substrate is a light shielding layer and the light transparent gaps are gaps in the light shielding layer. In one embodiment, the light transparent gaps are transparent to ultraviolet (UV) light.

In one embodiment, the first pixel control lines are gate lines and the polymer walls are substantially aligned with the gate lines. Alternatively, the first pixel control lines are data lines and the polymer walls are substantially aligned with the data lines. In one embodiment, second pixel control lines are disposed on the second flexible substrate that cross the first pixel control lines, and the polymer walls are also substantially aligned with the second pixel control lines.

In one embodiment, the polymer walls are shaped as straight lines that are continuous across at least one of pixel columns or pixel rows. Alternatively, the polymer walls are shaped as straight lines that are discontinuous across at least one of pixel columns or pixel rows.

In one embodiment, a liquid crystal material is located between the polymer walls.

In one embodiment, a column spacer overlaps with the light transparent gaps and is disposed between the first flexible substrate and second flexible substrate. The column spacer may also be surrounded by the polymer walls.

In one embodiment, disclosed is a method of manufacturing a flexible LCD device. A first flexible substrate is prepared, wherein a layer is disposed on the first flexible substrate. A second flexible substrate is prepared, wherein first pixel control lines are disposed on the second flexible substrate. Polymer walls are formed between the first flexible substrate and the second flexible substrate that maintain a cell gap between the first flexible substrate and the second flexible substrate. The polymer walls are substantially aligned with the first pixel control lines and light transparent gaps in the layer disposed on the first flexible substrate.

In one embodiment of the method, a mixture of a light-curable compound and liquid crystal is provided between the first flexible substrate and the second flexible substrate. The polymer walls are then formed by exposing the mixture to light via the light transparent gaps in the layer disposed on the first flexible substrate.

In one embodiment of the method, the polymer walls are formed by exposing the mixture to ultraviolet (UV) light via the light transparent gaps in the layer disposed on the first flexible substrate. In one embodiment of the method, the polymer walls are formed by providing a mask having a mask pattern that matches the light transparent gaps; and exposing the mixture to light via the mask pattern of the mask and the light transparent gaps in the layer disposed on the first flexible substrate.

In one embodiment of the method, second pixel control lines are disposed on the second flexible substrate that cross the first pixel control lines, and the polymer walls are formed to be substantially aligned with the second pixel control lines.

In one embodiment, preparing the first flexible substrate comprises forming a column spacer disposed on the first flexible substrate that overlaps with the light transparent gaps in the first flexible substrate. Additionally, the polymer walls are formed to surround the column spacer.

It is to be understood that both the foregoing general description and the following detailed description of embodiments of the present invention are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this application, illustrate embodiment(s) of the invention and together with the description serve to explain the principle of the invention. In the drawings:

FIG. **1**A is a perspective view schematically illustrating a related art LCD device, and FIG. **1**B is a cross sectional view schematically illustrating the related art LCD device;

FIG. **2**A is a plane view illustrating an upper substrate of an LCD device according to the first embodiment of the present invention, FIG. **2**B is a plane view illustrating a lower substrate of the LCD device according to the first embodiment of the present invention, FIG. **2**C is a plane view illustrating a polymer wall in the LCD device according to the first embodiment of the present invention, and FIG. **2**D is a cross sectional view of the LCD device according to the first embodiment of the present invention;

FIG. **3**A is a plane view illustrating an upper substrate of an LCD device according to the second embodiment of the present invention, and FIG. **3**B is a plane view illustrating a polymer wall in the LCD device according to the second embodiment of the present invention;

FIG. **4**A is a plane view illustrating an upper substrate of an LCD device according to the third embodiment of the present invention, and FIG. **4**B is a plane view illustrating a polymer wall in the LCD device according to the third embodiment of the present invention;

FIG. **5**A is a plane view illustrating an upper substrate of an LCD device according to the fourth embodiment of the present invention, and FIG. **5**B is a plane view illustrating a polymer wall in the LCD device according to the fourth embodiment of the present invention;

FIG. **6**A is a plane view illustrating an upper substrate of an LCD device according to the fifth embodiment of the present invention, FIG. **6**B is a plane view illustrating a lower substrate of the LCD device according to the fifth embodiment of the present invention, FIG. **6**C is a plane view illustrating a polymer wall in the LCD device according to the fifth embodiment of the present invention, and FIG. **6**D is a cross sectional view of the LCD device according to the fifth embodiment of the present invention;

FIG. **7**A is a plane view illustrating an upper substrate of an LCD device according to the sixth embodiment of the present invention, and FIG. **7**B is a plane view illustrating a polymer wall in the LCD device according to the sixth embodiment of the present invention;

FIG. **8**A is a plane view illustrating an upper substrate of an LCD device according to the seventh embodiment of the present invention, and FIG. **8**B is a plane view illustrating a polymer wall in the LCD device according to the seventh embodiment of the present invention;

FIG. **9**A is a plane view illustrating an upper substrate of an LCD device according to the eighth embodiment of the present invention, and FIG. **9**B is a plane view illustrating a polymer wall in the LCD device according to the eighth embodiment of the present invention; and

FIG. **10**A is a plane view illustrating an upper substrate of an LCD device according to the ninth embodiment of the present invention, and FIG. **10**B is a plane view illustrating a polymer wall in the LCD device according to the ninth embodiment of the present invention.

DETAILED DESCRIPTION

Hereinafter, embodiments of the present invention will be described in detail with reference to the accompanying drawings.

FIG. **2**A is a plane view illustrating an upper substrate of an LCD device according to the first embodiment of the present invention, FIG. **2**B is a plane view illustrating a lower substrate of the LCD device according to the first embodiment of the present invention, FIG. **2**C is a plane view illustrating a polymer wall in the LCD device according to the first embodiment of the present invention, and FIG. **2**D is a cross sectional view of the LCD device according to the first embodiment of the present invention.

As shown in FIG. **2**A, on an upper substrate **100** of an LCD device according to the first embodiment of the present invention, there are a light-shielding layer **110**, and a color filter layer **120** interspersed within the light-shielding layer **110**.

The light-shielding layer **110** prevents light from leaking in other regions except a pixel region for displaying an image. The light-shielding layer **110** may include a first light-shielding pattern **112**, a second light-shielding pattern **114**, and a third light-shielding pattern **116**.

The first light-shielding pattern **112** is formed in the circumference of the upper substrate **100**. That is, the first light-shielding pattern **112** is formed at the four sides of the upper substrate **100**, on which an image is not displayed.

The second light-shielding pattern **114** and third light-shielding pattern **116** are formed inside the first light-shielding pattern **112**. That is, the second light-shielding pattern **114** and third light-shielding pattern **116** are formed in the center of the upper substrate **100**, on which an image is displayed.

The second light-shielding pattern **114** is formed in a first direction, for example, a horizontal direction which is the same direction as that of a gate line on a lower substrate of the LCD device. The third light-shielding pattern **116** is formed in a second direction which is different from the first direction, for example, a vertical direction which is the same direction as that of a data line on the lower substrate of the LCD device.

Inside the second light-shielding pattern **114**, there is a light transparent part **114***a* that is transparent to UV light. Also, a light transparent part **116***a* is provided inside the third light-shielding pattern **116**. UV light penetrates through the light transparent part **116***a*. Light transparent part **114***a* and light transparent part **116***a* are gaps in the light shielding layer **110** and/or color filter layer **120**. When considered together or alone, light transparent part **114***a* and light transparent part **116***a* form a light transparent pattern that is transparent to UV light.

Accordingly, when the upper surface of the upper substrate **100** is irradiated with UV light, the UV light may not penetrate through the regions corresponding to the light-shielding layer **110** and color filter layer **120**, but the UV light may easily penetrate through the light transparent parts **114***a* and **116***a*. As a result, a polymer wall to be described may be formed in a pattern that corresponds to and matches the pattern of light transparent parts **114***a* and **116***a*.

As shown in FIG. **2**B, the gate lines **210** and data lines **220** crossing each other are formed on the lower substrate **200** of the LCD device, to thereby define a plurality of pixels. Gate lines and data lines carry pixel control signals for controlling the operation of the pixels. As used herein, the term pixel control lines may be used to refer to either the gate lines **210** or the data lines **220**.

The gate lines **210** are parallel to each other and formed in the first direction, for example, the horizontal direction which is the same direction as that of the aforementioned second light-shielding pattern **114**. The data lines **220** are parallel to each other and formed in the second direction which is different from the first direction, for example, the vertical direction which is the same direction as that of the aforementioned third light-shielding pattern **116**.

At crossing regions of the gate lines **210** and data lines **220**, there are thin film transistors T which function as switching elements. The thin film transistors T are electrically connected to their respective pixel electrodes **230**.

In one embodiment, the detailed structure of the upper substrate **100** and lower substrate **200** may be different depending on a driving mode of the LCD device, for example, Twisted Nematic (TN) mode, Vertical Alignment (VA) mode, In-Plane Switching (IPS) mode, Fringe Field Switching (FFS) mode, and etc.

As shown in FIG. **2**C, the polymer wall **300** of the LCD device according to the first embodiment of the present invention may include a first wall pattern **310**, and a second wall pattern **320**.

The polymer wall **300** is formed in the pattern which corresponds to the light transparent parts **114***a* and **116***a* included in the aforementioned second light-shielding pattern **114** and third light-shielding pattern **116**. That is, the first wall pattern **310** is arranged in the first direction, that is, the direction which is the same direction as that of the light transparent part **114***a* included in the second light-shielding pattern **114**. First wall pattern **310**, gate lines **210**, and light transparent part **114***a* are all substantially aligned with each other. The second wall pattern **320** is arranged in the second direction, that is, the direction which is the same as that of the light transparent part **116***a* included in the third light-shielding pattern **116**. Second wall pattern **320**, data lines **220**, and light transparent part **116***a* are all substantially aligned with each other.

Hereinafter, a cross sectional structure of the LCD device according to the first embodiment of the present invention and a method of manufacturing the same will be described with reference to FIG. **2**D.

As shown in FIG. **2**D, the third light-shielding pattern **116** including the light transparent part **116***a* therein is formed on the upper substrate **100**, and the color filter layer **120** is formed in the gaps between each of the third light-shielding patterns **116**. The upper substrate **100** may be formed of flexible plastic.

The color filter layer **120** may overlap with the third light-shielding pattern **116**, but the color filter layer **120** is not overlapped with the light transparent part **116***a*. If the color filter layer **120** extends to the light transparent part **116***a*, it is difficult to obtain a desired pattern of the polymer wall **300**. For this reason, the color filter layer **120** is not overlapped with the light transparent part **116***a*.

An overcoat layer **130** may be formed on the color filter layer **120**. If the LCD device is a TN mode or VA mode, a common electrode may be formed instead of the overcoat layer **130**.

As shown in an expanded part of FIG. **2**D, a column spacer **140** is formed on the overcoat layer **130**. The column spacer **140** is provided to maintain an initial cell gap before forming the polymer wall **300**. The column spacer **140** is bonded to the upper substrate **100**, but is not bonded to the lower substrate **200**.

The column spacer **140** may be formed in a non-display area, for example, an area for the gate line or data line. That is, the column spacer **140** may overlap with the light transparent part **116***a*. Accordingly, if a width of the column spacer **140** is smaller than the light transparent part **116***a*, as shown in an upper expanded part of FIG. **2**D, the column spacer **140** may be surrounded by the polymer wall **300**. However, if a width of the column spacer **140** is larger than the light transparent part, as shown in a lower expanded part of FIG. **2**D, the column spacer **140** is not surrounded by the polymer wall **300**.

Meanwhile, the column spacer **140** may be formed in a region which does not correspond to the gate line or data line, for example, the column spacer **140** may be formed in a region of forming the thin film transistor.

As shown in the following description about the embodiments of the present invention, the light transparent part may not be formed in the region which corresponds to some parts of the gate line or data line. In this case, the column spacer **140** may be formed in the gate line or data line which corresponds to the region where the light transparent part is not formed.

A gate insulating film **215** is formed on the lower substrate **200**, and the data line **220** is formed on the gate insulating film **215**. The lower substrate **200** may be formed of flexible plastic. Also, a passivation film **225** is formed on the data line **220**, and a pixel electrode **230** is formed on the passivation film **225**. If the LCD device is an IPS mode, the pixel electrode **230** may be formed in a finger structure, and a common electrode may be additionally provided in parallel to the pixel electrode **230**.

The polymer wall **300** for maintaining the cell gap is formed between the upper substrate **100** and lower substrate **200**, and liquid crystal **400** is provided between each of the polymer walls **300**.

The polymer wall **300** overlaps and is aligned with the light transparent part **116***a* included in the third light-shielding pattern **116** on the upper substrate **100**. Also, the polymer wall **300** overlaps and is aligned with the data line **220** on the lower substrate **200**. Since the polymer wall **300** overlaps and is aligned with the data line **220**, light transmittance of the LCD device is not lowered by the polymer wall **300**.

A method of manufacturing the LCD device according to the first embodiment of the present invention will be described in detail as follows.

First, the aforementioned upper substrate **100** and lower substrate **200** are prepared.

Then, while a mixture of UV-curable compound and liquid crystal **400** is provided to a space between the upper substrate **100** and lower substrate **200**, the upper substrate **100** and lower substrate **200** are bonded to each other. The mixture may include additional photo-initiator. The UV-curable compound and photo-initiator may be formed of various materials generally known to those in the art.

A bonding process of the upper substrate **100** and lower substrate **200** may be carried out by a vacuum injection method or liquid crystal dispensing method. In case of the vacuum injection method, after the upper substrate **100** and lower substrate **200** are attached to each other by the use of sealant having an inlet, the mixture of UV-curable compound and liquid crystal **400** is injected through the inlet under the vacuum state. In case of the liquid crystal dispensing method, after the mixture of UV-curable compound and liquid crystal **400** is dispensed on any one of the upper substrate **100** and lower substrate **200**, the upper substrate **100** and lower substrate **200** are attached to each other by the use of sealant without an inlet.

Then, the UV-curable compound is cured by a UV irradiation onto the upper surface of the upper substrate **100**. That is, when UV light is irradiated onto the upper surface of the upper substrate **100** without using an additional mask, UV light is incident on the UV-curable compound through the light transparent parts **114***a* and **116***a* included in the light-shielding layer **110**. Thus, the UV-curable compound is cured with a phase separation from the liquid crystal **400**, whereby the polymer wall **300** is formed, and the liquid crystal **400** is formed between each of the polymer walls **300**.

Even though the light transmittance is lowered, there is a possibility that UV light may penetrate through the color filter layer **120**. In this case, a desired shape of the polymer wall **300** may not be obtained. In one embodiment, an additional mask is positioned above the upper substrate **100** for controlling the irradiation of UV light onto the upper surface of the upper substrate **100**. In this case, the additional mask may be provided with a transparent mask pattern whose pattern is the same as and matches that of the light transparent part **114***a* and **116***a*.

As described above, the present invention is advantageous in that it can be applied to various types of LCD device owing to the UV irradiation onto the upper surface of the upper substrate **100**. Especially, because the light-shielding layer **110** and color filter layer **120** are used as a mask, the UV irradiation is carried out without an additional mask, whereby it is possible to reduce a cost and to simplify a manufacturing process.

Second, third, and fourth embodiments of a LCD device will now be described herein by reference to FIGS. **3**A, **3**B, **4**A, **4**B, **5**A and **5**B. The second, third and fourth embodiments are similar to the first embodiment of FIG. **2**A through **2**D, except that the light-shielding layer **110** and polymer wall **300** now have a different pattern than that of the first embodiment.

FIG. **3**A is a plane view illustrating an upper substrate of an LCD device according to the second embodiment of the present invention. FIG. **3**B is a plane view illustrating a polymer wall in the LCD device according to the second embodiment of the present invention.

According to the second embodiment of the present invention, as shown in FIG. **3**A, a light-shielding layer **110** is formed on an upper substrate **100**, and a color filter layer **120** is formed in the gaps of the light-shielding layers **110**.

The light-shielding layer **110** may include a first light-shielding pattern **112**, a second light-shielding pattern **114**, and a third light-shielding pattern **116**.

The second light-shielding pattern **114** is not provided with a light transparent part, and the third light-shielding pattern **116** is provided with a light transparent part **116***a*. Thus, when the upper surface of the upper substrate **100** is irradiated with UV light, UV light penetrates through the light transparent part **116***a* included in the third light-shielding pattern **116**.

Eventually, as shown in FIG. **3**B, a polymer wall **300** in the LCD device according to the second embodiment of the present invention comprises a second wall pattern **320** which corresponds to the light transparent part **116***a* included in the third light-shielding pattern **116**.

FIG. **4**A is a plane view illustrating an upper substrate of an LCD device according to the third embodiment of the present invention. FIG. **4**B is a plane view illustrating a polymer wall in the LCD device according to the third embodiment of the present invention.

According to the third embodiment of the present invention, as shown in FIG. **4**A, a light-shielding layer **110** is formed on an upper substrate **100**, and a color filter layer **120** is formed between each of the light-shielding layers **110**.

The light-shielding layer **110** may include a first light-shielding pattern **112**, a second light-shielding pattern **114**, and a third light-shielding pattern **116**.

The second light-shielding pattern **114** is provided with a light transparent part **114***a*, and the third light-shielding pattern **116** is not provided with a light transparent part. Thus, when the upper surface of the upper substrate **100** is irradiated with UV light, UV light penetrates through the light transparent part **114***a* included in the second light-shielding pattern **114**.

Eventually, as shown in FIG. **4**B, a polymer wall **300** in the LCD device according to the third embodiment of the present invention comprises a first wall pattern **310** which corresponds to the light transparent part **114***a* included in the second light-shielding pattern **114**.

FIG. **5**A is a plane view illustrating an upper substrate of an LCD device according to the fourth embodiment of the present invention. FIG. **5**B is a plane view illustrating a polymer wall in the LCD device according to the fourth embodiment of the present invention.

According to the fourth embodiment of the present invention, as shown in FIG. **5**A, a light-shielding layer **110** is formed on an upper substrate **100**, and a color filter layer **120** is formed between each of the light-shielding layers **110**.

The light-shielding layer **110** may include a first light-shielding pattern **112**, a second light-shielding pattern **114**, and a third light-shielding pattern **116**.

The second light-shielding pattern **114** is provided with a light transparent part **114***a*, and the third light-shielding pattern **116** is not provided with a light transparent part.

The light transparent part **114***a* is not formed in a crossing region of the second light-shielding pattern **114** and third light-shielding pattern **116**. Thus, the light transparent part **114***a* is formed in a discontinuous straight line that has multiple segments. That is, according to the aforementioned third embodiment of the present invention, the light transparent part **114***a* is formed in a cross region of the second light-shielding pattern **114** and third light-shielding pattern **116**, whereby the light transparent part **114***a* is formed in a continuous straight line that is continuous across different pixel columns. However, in case of the fourth embodiment of the present invention, the light transparent part **114***a* is not formed in the crossing region of the second light-shielding pattern **114** and third light-shielding pattern **116**, whereby the light transparent part **114***a* is formed in the discontinuous straight line that is discontinuous across different pixel columns.

Eventually, as shown in FIG. **5**B, a polymer wall **300** in the LCD device according to the fourth embodiment of the present invention comprises a first wall pattern **310** of a discontinuous straight line which corresponds to the light transparent part **114***a* included in the second light-shielding pattern **114**. The discontinuous straight line includes several segments that are discontinuous across different pixel columns.

In the above second embodiment of FIG. **3**A, although not shown, the light transparent part **116***a* may not be formed in a crossing region of the second light-shielding pattern **114** and third light-shielding pattern **116**, that is, the light transparent part **116***a* may be formed in a discontinuous straight line that is discontinuous across different pixel rows, whereby the second wall pattern **320** may be a discontinuous straight line that is discontinuous across different pixel rows.

FIG. **6**A is a plane view illustrating an upper substrate **100** of an LCD device according to the fifth embodiment of the present invention, FIG. **6**B is a plane view illustrating a lower substrate **200** of the LCD device according to the fifth embodiment of the present invention, FIG. **6**C is a plane view illustrating a polymer wall **300** in the LCD device according to the fifth embodiment of the present invention, and FIG. **6**D is a cross sectional view of the LCD device according to the fifth embodiment of the present invention, wherein FIG. **6**D is a cross sectional view along I-I of FIGS. **6**A and **6**B. The fifth embodiment is similar to the first embodiment of FIG. **2**A-**2**D, but the light-shielding layer **110** now has a different appearance. For the following description, a detailed explanation for structures that have already been described for the first embodiment will be omitted.

As shown in FIG. **6**A, a light-shielding layer **110** and a color filter layer **120** are formed on an upper substrate **100** of an LCD device according to the fifth embodiment of the present invention.

The light-shielding layer **110** is not formed in the center of the upper substrate **100** on which an image is displayed. That is, the light-shielding layer **110** may comprise a first light-shielding pattern **112** which is formed in the circumference of the upper substrate **100**.

The color filter layer **120** is formed to correspond with a plurality of pixels. The color filter layer **120** is not formed in a boundary region between each of the pixels, and more particularly, in a region corresponding to a gate line **210** and data line **220** on a lower substrate **200**. That is, the color filter layer **120** includes a light transparent part **120***a* which is formed in a region corresponding to the gate line **210** and data line **220**. Thus, when the upper surface of the upper substrate **100** is irradiated with UV light, UV light easily penetrates through the light transparent part **120***a* of the color filter layer **120**. As a result, a polymer wall **300** may be formed in a pattern corresponding to the pattern of the light transparent part **120***a*.

As shown in FIG. **6**B, the gate lines **210** and data lines **220** crossing each other are formed on the lower substrate **200** of the LCD device according to the fifth embodiment of the present invention, wherein the gate lines **210** are arranged in a first direction, and the data lines **220** are arranged in a second direction. At a crossing region of the gate lines **210** and data lines **220**, there are thin film transistors T. The thin film transistors T are electrically connected to their respective pixel electrodes **230**.

As shown in FIG. **6**C, the polymer wall **300** in the LCD device according to the fifth embodiment of the present invention may include a first wall pattern **310**, and a second wall pattern **320**.

The polymer wall **300** is formed in a pattern which corresponds to the light transparent part **120***a*. That is, the first wall pattern **310** is arranged in the first direction, that is, the direction which is the same direction as that of the light transparent part **120***a* corresponding to the gate line **210**, and the second wall pattern **320** is arranged in the second direction, that is, the direction which is the same as that of the light transparent part **120***a* corresponding to the data line **220**.

Hereinafter, a cross sectional structure of the LCD device according to the fifth embodiment of the present invention and a method of manufacturing the same will be described with reference to FIG. **6**D.

As shown in FIG. **6**D, the color filter layer **120** including the light transparent part **120**a therein is formed on the upper substrate **100**, and an overcoat layer **130** is formed on the color filter layer **120**.

A gate insulating film **215** is formed on the lower substrate **200**, and the data line **220** is formed on the gate insulating film **215**. Also, a passivation film **225** is formed on the data line **220**, and a pixel electrode **230** is formed on the passivation film **225**.

The polymer wall **300** for maintaining the cell gap is formed between the upper substrate **100** and lower substrate **200**, and liquid crystal **400** is provided between each of the polymer walls **300**.

The polymer wall **300** may overlap with the light transparent part **120**a included in the color filter layer **120** on the upper substrate **100**. Also, the polymer wall **300** may overlap with the data line **220** on the lower substrate **200**.

Hereinafter, a method of manufacturing the LCD device according to the fifth embodiment of the present invention will be described in detail as follows.

First, the aforementioned upper substrate **100** and lower substrate **200** are prepared.

While a mixture of UV-curable compound and liquid crystal **400** is provided to a space between the upper substrate **100** and lower substrate **200**, the upper substrate **100** and lower substrate **200** are bonded to each other. The mixture may include additional photo-initiator.

Then, the UV-curable compound is cured by irradiating UV light onto the upper surface of the upper substrate **100**. That is, when UV light is irradiated onto the upper surface of the upper substrate **100**, UV light is incident on the UV-curable compound through the light transparent part **120**a included in the color filter layer **120**. Thus, the UV-curable compound is cured with a phase separation from the liquid crystal **400**, whereby the polymer wall **300** is formed, and the liquid crystal **400** is formed between each of the polymer walls **300**.

Sixth, seventh, eighth and ninth embodiments of a LCD device will now be described herein by reference to FIGS. **7**A, **7**B, **8**A, **8**B, **9**A, **9**B, **10**A and **10**B. The sixth, seventh, eight, and ninth embodiments are similar to the fifth embodiment of FIG. **6**A through **6**D, except that the color filter layer **120**, light-shielding layer **110** and polymer wall **300** now have a different pattern than that of the fifth embodiment.

FIG. **7**A is a plane view illustrating an upper substrate **100** of an LCD device according to the sixth embodiment of the present invention, and FIG. **7**B is a plane view illustrating a polymer wall **300** in the LCD device according to the sixth embodiment of the present invention.

According to the sixth embodiment of the present invention, as shown in FIG. **7**A, a light-shielding layer **110** including a first light-shielding pattern **112** is formed in the circumference of an upper substrate **100**, and a color filter layer **120** is formed in the center of the upper substrate **100**.

The color filter layer **120** includes a light transparent part **120**a therein. In this case, the light transparent part **120**a is not formed in a region corresponding to a gate line **210** of a lower substrate **200**, and the light transparent part **120**a is formed in a region corresponding to a data line **220**.

That is, the color filter layer **120** is not formed in a boundary region between each of the pixels in a row of pixels arranged along a horizontal direction. However, the color filter layer **120** is formed in a boundary region (B) between each of the pixels in a column of pixels arranged along a vertical direction.

Thus, when the upper surface of the upper substrate **100** is irradiated with UV light, UV light easily penetrates through the light transparent part **120**a which is formed in the region corresponding to the data line **220**.

As a result, as shown in FIG. **7**B, a polymer wall **300** in the LCD device according to the sixth embodiment of the present invention may include a second wall pattern **320** corresponding to the light transparent part **120**a included in the aforementioned color filter layer **120**.

FIG. **8**A is a plane view illustrating an upper substrate **100** of an LCD device according to the seventh embodiment of the present invention, and FIG. **8**B is a plane view illustrating a polymer wall **300** in the LCD device according to the seventh embodiment of the present invention.

According to the seventh embodiment of the present invention, as shown in FIG. **8**A, a light-shielding layer **110** including a first light-shielding pattern **112** is formed in the circumference of an upper substrate **100**, and a color filter layer **120** is formed in the center of the upper substrate **100**.

The color filter layer **120** includes a light transparent part **120**a therein. In this case, the light transparent part **120**a is formed in a region corresponding to a gate line **210** of a lower substrate **200**, and the light transparent part **120**a is not formed in a region corresponding to a data line **220**.

That is, the color filter layer **120** is formed in a boundary region (B) between each of the pixels in a row of pixels arranged along a horizontal direction. However, the color filter layer **120** is not formed in a boundary region between each of the pixels in a column of pixels arranged along a vertical direction.

Thus, when the upper surface of the upper substrate **100** is irradiated with UV light, UV light easily penetrates through the light transparent part **120**a which is formed in the region corresponding to the gate line **210**.

As a result, as shown in FIG. **8**B, a polymer wall **300** in the LCD device according to the seventh embodiment of the present invention may include a first wall pattern **310** corresponding to the light transparent part **120**a included in the aforementioned color filter layer **120**.

FIG. **9**A is a plane view illustrating an upper substrate of an LCD device according to the eighth embodiment of the present invention, and FIG. **8**B is a plane view illustrating a polymer wall in the LCD device according to the eighth embodiment of the present invention.

According to the eighth embodiment of the present invention, as shown in FIG. **9**A, a light-shielding layer **110** and a color filter layer **120** are formed on an upper substrate **100**.

The light-shielding layer **110** may include a first light-shielding pattern **112** formed in the circumference of the upper substrate **100**, and a second light-shielding pattern **114** formed in the center of the upper substrate **100**.

The color filter layer **120** includes a light transparent part **120**a therein. In this case, the light transparent part **120**a is formed in a region corresponding to a data line **220** of a lower substrate **200**, that is, a region where the second light-shielding pattern **114** is not formed.

Thus, when the upper surface of the upper substrate **100** is irradiated with UV light, UV light easily penetrates through the light transparent part **120**a which is formed in the region corresponding to the data line **220**.

As a result, as shown in FIG. **9**B, a polymer wall **300** in the LCD device according to the eighth embodiment of the present invention may include a second wall pattern **320** corresponding to the light transparent part **120**a included in the aforementioned color filter layer **120**.

Although not shown in FIG. **9**A, the light-shielding layer **110** may include a third light-shielding pattern **116** arranged in a second (vertical) direction, instead of the second light-shielding pattern **114** arranged in a first (horizontal) direction.

In this case, a finally-obtained polymer wall **300** may include a first wall pattern arranged in the first (horizontal) direction.

FIG. **10**A is a plane view illustrating an upper substrate of an LCD device according to the ninth embodiment of the present invention, and FIG. **10**B is a plane view illustrating a polymer wall in the LCD device according to the ninth embodiment of the present invention.

According to the ninth embodiment of the present invention, as shown in FIG. **10**A, a light-shielding layer **110** and a color filter layer **120** are formed on an upper substrate **100**.

The light-shielding layer **110** may include a first light-shielding pattern **112** formed in the circumference of the upper substrate **100**, and a second light-shielding pattern **114** formed in the center of the upper substrate **100**.

In the aforementioned eighth embodiment of the present invention, the second light-shielding pattern **114** is formed in a discontinuous straight line that is discontinuous across pixel columns, and thus the light transparent part **120***a* included in the color filter layer **120** is formed in a continuous straight line that is continuous across pixel rows. Thus, the polymer wall **300** includes the second wall pattern **320** which is formed in a continuous straight line.

On the contrary, according to the ninth embodiment of the present invention, the second light-shielding pattern **114** is formed in a continuous straight line that is continuous across pixel columns, and thus a light transparent part **120***a* is formed in a discontinuous straight line that is discontinuous across difference pixel rows. As a result, as shown in FIG. **10**B, a polymer wall **300** includes a second wall pattern **320** which is formed in a discontinuous straight line that includes several segments and is also discontinuous across different pixel rows.

Although not shown in FIG. **10**A, the light-shielding layer **110** may include a third light-shielding pattern **116** arranged in a second (vertical) direction, instead of the second light-shielding pattern **114** arranged in a first (horizontal) direction. In this case, a finally-obtained polymer wall may include a first wall pattern arranged in the first (vertical) direction.

According to embodiments of the present invention, since the polymer wall **300** may overlap with the gate line **210** or data line **220**, light transmittance of the LCD device is not lowered by the polymer wall **300**. Also, the UV irradiation may be applied to the upper surface of the upper substrate **100**, whereby it may be applied to the manufacturing process of the various structures of the LCD device.

It will be apparent to those skilled in the art that various modifications and variations can be made to embodiments of the present invention without departing from the spirit or scope of the invention. Thus, it is intended that the present invention covers the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.

What is claimed is:

1. A flexible liquid crystal display (LCD) device comprising:
- a first flexible substrate;
- a layer disposed on the first flexible substrate;
- a second flexible substrate;
- first pixel control lines disposed on the second flexible substrate, the first pixel control lines being at least one of data lines or gate lines; and
- polymer walls disposed between the first flexible substrate and the second flexible substrate that maintain a cell gap between the first flexible substrate and the second flexible substrate, wherein the polymer walls are substantially aligned with and overlap with the first pixel control lines and light transparent gaps in the layer disposed on the first flexible substrate, both the polymer walls and the light transparent gaps in the layer being discontinuous across at least one of pixel columns or pixel rows.

2. The LCD device of claim **1**, wherein the layer disposed on the first flexible substrate is a color filter layer and the light transparent gaps are gaps in the color filter layer.

3. The LCD device of claim **1**, wherein the layer disposed on the first flexible substrate is a light shielding layer and the light transparent gaps are gaps in the light shielding layer.

4. The LCD device of claim **1**, wherein the first pixel control lines are gate lines and the polymer walls are substantially aligned with the gate lines.

5. The LCD device of claim **1**, wherein the first pixel control lines are data lines and the polymer walls are substantially aligned with the data lines.

6. The LCD device of claim **1**, wherein the light transparent gaps are transparent to ultraviolet (UV) light.

7. A flexible liquid crystal display (LCD) device comprising:
- a first flexible substrate;
- a layer disposed on the first flexible substrate;
- a second flexible substrate;
- first pixel control lines disposed on the second flexible substrate; and
- polymer walls disposed between the first flexible substrate and the second flexible substrate that maintain a cell gap between the first flexible substrate and the second flexible substrate, wherein the polymer walls are substantially aligned with the first pixel control lines and light transparent gaps in the layer disposed on the first flexible substrate, both the polymer walls and the light transparent gaps shaped as straight lines that are discontinuous across at least one of pixel columns or pixel rows.

8. The LCD device of claim **1**, further comprising:
- a liquid crystal material located between the polymer walls.

9. A flexible liquid crystal display (LCD) device comprising:
- a first flexible substrate;
- a layer disposed on the first flexible substrate;
- a second flexible substrate;
- first pixel control lines disposed on the second flexible substrate;
- polymer walls disposed between the first flexible substrate and the second flexible substrate that maintain a cell gap between the first flexible substrate and the second flexible substrate, wherein the polymer walls are substantially aligned with the first pixel control lines and light transparent gaps in the layer disposed on the first flexible substrate; and
- a column spacer disposed between the first flexible substrate and second flexible substrate and overlapping with a light transparent gap of the light transparent gaps, a width of the column spacer being smaller than a width of the light transparent gap and the column spacer being surrounded by a polymer wall of the polymer walls.

10. A method of manufacturing a flexible liquid crystal display (LCD) device, comprising:
- preparing a first flexible substrate, wherein a layer is disposed on the first flexible substrate;
- preparing a second flexible substrate, wherein first pixel control lines are disposed on the second flexible substrate;
- providing a mixture of a light-curable compound and liquid crystal between the first flexible substrate and the second flexible substrate;

providing a mask having a mask pattern that matches light transparent gaps in the layer disposed on the first flexible substrate; and

forming polymer walls between the first flexible substrate and the second flexible substrate that maintain a cell gap between the first flexible substrate and the second flexible substrate, the polymer walls being substantially aligned with the first pixel control lines and the light transparent gaps in the layer disposed on the first flexible substrate, the polymer walls formed by exposing the mixture to light via the mask pattern of the mask and the light transparent gaps in the layer disposed on the first flexible substrate.

11. The method of claim **10**, wherein forming the polymer walls comprises:

forming the polymer walls by exposing the mixture to ultraviolet (UV) light via the light transparent gaps in the layer disposed on the first flexible substrate.

12. The method of claim **10**, wherein second pixel control lines that cross the first pixel control lines are disposed on the second flexible substrate, and where the polymer walls are formed to be substantially aligned with the second pixel control lines.

13. A method of manufacturing a flexible liquid crystal display (LCD) device, comprising:

preparing a first flexible substrate, wherein a layer is disposed on the first flexible substrate and a column spacer is disposed on the first flexible substrate that overlaps with a light transparent gap of light transparent gaps in the layer, a width of the column spacer being smaller than a width of the light transparent gap; and

preparing a second flexible substrate, wherein first pixel control lines are disposed on the second flexible substrate; and

forming polymer walls between the first flexible substrate and the second flexible substrate that maintain a cell gap between the first flexible substrate and the second flexible substrate, the polymer walls being substantially aligned with the first pixel control lines and the light transparent gaps in the layer disposed on the first flexible substrate, the column spacer being surrounded by a polymer wall of the polymer walls.

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